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Two sets of studies were conducted which dealt with problems of teaching machine programming and teaching machine design. One set dealt with the variable of student response for the purpose of determining whether teaching machine programs should require students to make an overt response, and if so, what type of response. A second set dealt with variables affecting the design of machine to determine whether external pacing of the student was undesirable, and whether the teaching machine possesses motivational properties. Results indicated that requiring students to make overt responses does not facilitate programed learning, that pacing the learner will not impair his performance if care is taken to ascertain optimal pacing rates, that teaching machines do not provide a significant advantage over programed textbooks, and that need to require students to make any form of constructed response remains to established. While overt responses may not be necessary insofar as learning is concerned, experimenters were not willing to recommend that programs be written to eliminate the need for student response. It was felt important to recognize that the constructed response (overt or covert) may not play a central role in learning, but it could be useful in a wide variety of programed learning situations. It was recommended that experimental work be done to determine methods of pacing students in programed learning situations, since such information may prove to be useful in training. Numercus tables accompany the text.

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Technical Report: NAVTRADEVCEN 507-3

RESPONSE MODE, PACING, AND MOTIVATIONAL EFFECTS IN TEACHING MACHINES

U.S. NAVAL TRAINING DEVICE CENTER
PORT WASHINGTON, L.I., NEW YORK

Technical Report: NAVTRADEVCEN 507-3

RESPONSE MODE, PACING, AND MOTIVATIONAL EFFECTS IN TEACHING MACHINES

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ABSTRACT

RESPONSE MODE, PACING, AND MOTIVATIONAL EFFECTS IN TEACHING MACHINES

Three experiments were performed to study the effects of response mode; one experiment was done to study pacing and one experiment dealt with the motivational effects of teaching machines. The first three experiments indicated that requiring the student to make an overt response does not facilitate programmed learning, nor is the constructing of a response, whether it be overt or covert, necessarily advantageous. The fourth experiment indicated that pacing will not impair performance if care is taken to insure optimal pacing rates. The fifth experiment gave no evidence of motivational effects in teaching machines: programmed textbooks were as effective as teaching machines.

FOREWORD

Purpose

The U. S. Naval Training Device Center is actively engaged in research on automated tutors (teaching machines) because of the important potential of the use of such devices in Navy training. Since the use of automated tutors involves a new and untried training approach, the U. S. Naval Training Device Center has instituted a series of research studies to find out how best to use the automated tutors. Previous studies have involved the type of item (multiple-choice, true-false, and completion), method of presentation (traditional versus automated), and the physical characteristics of cues as important variables.

This report describes pilot studies concerning the following points:

1. Is the way the student responds important? Theoreticians in psychology have diverging views on this topic.

2. Is it important to respond overtly?

3. Will pacing the study time (specifying the time available per item) yield results different from allowing a student to proceed at his own rate?

4. Does a complex teaching machine provide better learning than one not so complex?

Experimental Conditions

Since this research is exploratory, due notice must be taken of the following points which would at present limit its immediate applicability:

1. The character of the programming; in subject matter, use of small steps from item to item, and low error rate.

2. Use of college students, whose motivation and learning ability may differ significantly from that of Navy recruits.

3. Shortness of learning period -- learning on the teaching machines for a period of one to two hours.

Results

The results of this study can be summarized as follows:

1. When the student is paced on a machine it makes no difference what form the response takes (thinking, writing, speaking, or speaking-writing).

2. Whether paced or not, reading the item only (no response) is just as effective as writing the response when using a machine.

3. Without pacing no significant differences were obtained between:

   a. teaching machine and programmed booklet.

   b. responding (writing) and not responding.

4. No differences in learning were obtained when a complex machine, a crude machine, or a programmed booklet was used.

Implications

The implications stemming from this study are such as to merit careful consideration. Specifically, the following are worthy of attention:

1. Pacing appears to be feasible and may serve to shorten learning time.

2. Type of response for low error rate programs may not be crucial.

3. A complex electromechanical machine as opposed to simpler types of teaching machines as such does not facilitate learning over short period of time.

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RECOMMENDATIONS

The results of the five experiments reported here indicate:

1. Requiring the students to make an overt response does not facilitate programmed learning.

2. The need to require students to make any form of constructed response remains to be established. Students who were given teaching machine programs containing no blanks learned as well or, in some situations, better than those who were required to construct a response in order to complete a blank.

3. Pacing the learner will not impair his performance if care is taken to ascertain optimal pacing rates.

4. Teaching machines do not provide a significant advantage over programmed textbooks. There was no evidence of any novelty effects inherent in the machines.

On the basis of these findings the following recommendations are made:

1. While overt responses may not be necessary in so far as learning per se is concerned, we are not willing to recommend that programs be written which eliminate the need for student responding. If responses do not foster learning, they may still provide the necessary external controls to keep an unmotivated S at the task long enough for him to derive reinforcement from his own progress. Furthermore, the overt responses can provide the programmer qua teacher with necessary information about the progress of the student. Thus, we feel it may be important to recognize that the constructed response (overt or covert) may not play a central role, but that it can be a useful adjunct in a wide variety of programmed learning situations.

2. Further experimental work should be done to determine methods of pacing students in programmed learning situations. Such information may be very useful in training situations where time factors are important.

3. There is little reason at this time to be concerned with machine devices. The programmed text appears to be as effective as a machine. While machines may provide certain controls, such as preventing the learner from looking ahead or back, the extent to which these controls are necessary with adult learners has not been determined. There may be reason to believe that such controls will be useful with relatively undisciplined learners (children or reluctant students and trainees). However, questions regarding the extent and necessity of such controls can only be answered through further research.

BRIEF OF THE STUDY

The experiments reported below are concerned with certain problems of teaching machine programming and teaching machine design. One set of studies (Experiments I, IIA, and IIB) deals with the variable of student response. The purpose of these studies was to determine whether teaching machine programs should require the students to make an overt response and if so, what type of response is best. A second set of studies (Experiments III and IV) deals with variables affecting the design of machines. These studies were aimed at the following two questions: (a) Is external pacing of the student undesirable? and (b) Does the teaching machine qua machine possess motivational properties?

EXPERIMENT I

PROBLEM

The purpose of this experiment was to investigate the factor of response mode in order to determine whether a student should make overt responses during automated learning. While most investigators concede that active student participation fosters learning, there is no real agreement about the role of the overt response. In fact, Evans, Glaser, and Homme (1959) report that students who made no overt response took less time to go through a program in "Fundamentals of Music" and did slightly better on a criterion test than did students who were required to write their responses.

Experiment I was designed to test the hypothesis that students who are required to make an overt response on each item of a teaching machine program will show better learning than students who do not make overt responses. Three kinds of overt responses were studied: (a) writing, (b) speaking, and (c) writing and speaking. The Ss in a fourth group referred to as the covert response group were instructed simply to "think" their responses.

METHOD

THE EXPERIMENTAL SAMPLE

The Ss were 75 students drawn from the University College of Arts and Science and the College of Engineering of New York University. The Ss were volunteers and were paid at the rate of $1.50 per hour for their time. The Ss. used were selected on the basis of a preliminary test designed to measure familiarity with the learning material (see Appendix A). This test served to screen those Ss who prior to the experiment had extensive familiarity with the material, and those whose science backgrounds were so poor that they would require prior training before they could deal with the learning material in the experiment. A total of 105 Ss was tested in order to choose the 75 Ss for the experiment.

MATERIALS

The teaching machine was the disk machine designed by B. F. Skinner (U. S. Naval Training Device Center Device 11H7 (1958). All the Ss were

paced by means of signals; that is, they were exposed to each item for a similar period of time in order to keep item exposure time constant for each group. The pacing was accomplished by means of a General Electric synchronous motor timer connected to a buzzer. The timer was adjusted to allow each S 20 secs. per item on the first disk and 35 secs. per item on the second and third disks.

The learning material consisted of an 87-item unit dealing with basic electricity. Sample items are presented in Appendix A. The items were arranged on three disks of 29 items each. The criterion measure of learning was a 22-question examination consisting of 14 multiple-choice questions and 8 fill-in-the-blank items. This test is presented in Appendix A.

PROCEDURE

Each S was given the preliminary test and if his score was within the accepted range (more than 4 and not more than 11 incorrect items), he was introduced to the second phase of the study by being presented with a set of written instructions. Each S was assigned at random to one of five groups and the instructions he was given depended upon the group to which he was assigned. The instructions for each of the groups are presented in Appendix A. A description of the experimental conditions is presented below. When the S had read the instructions, the experimenter reviewed points which might not have been clear, and then he demonstrated the operation of the machine (providing the S was in one of the four learning groups).

The four learning groups were: (a) the covert response group in which Ss were instructed (Appendix A) to "think" the word or words that completed the blanks; (b) the speaking group in which Ss were required to say aloud the word or words that completed the blank; (c) the writing group in which Ss were required to write the response word or words, and (d) the writing-speaking group in which Ss were required to write and speak the response word or words.

A fifth group referred to as the no-learning group was included in this study. The Ss in this group were not exposed to the learning materials, but instead were presented with certain stimuli designed to encourage recall and recognition of basic electricity. This group served as a control group for all four of the learning groups. Since it was not possible to assume that the Ss' mastery of the subject matter prior to the experiment was close to zero, we felt that it was necessary to separate new learning from old learning and the control group was used for that purpose.

All Ss were given the final examination. The examination was scored for the number of errors on the fill-in-the-blank section and for total errors (including the multiple-choice items).

RESULTS AND DISCUSSION

The results of Experiment I are summarized in Table 1, where the means and SDs of the number of errors for each of the groups are presented for the preliminary test, for the fill-ins test, and for the total test. The asterisks in the table indicate which of the groups' test scores differ sig-

nificantly from the control group's test scores. The table of t tests for these data is shown in Table 9, Appendix A. Table 1 shows that there were no differences on the preliminary test. None of the learning groups differed from the control group. The fill-ins test and total test showed that the covert, speaking, and writing groups differed from the no-learning group. The writing-speaking group test scores were not different from the no-learning group.

Table 1

Means and SDs for the Preliminary, Fill-ins, and Total Test Error Scores for Experiment I
N =15 for Each Group

	Preliminary		Fill-ins		Total	
Group	Mean	SD	Mean	SD	Mean	SD
Covert	5.33	1.29	2.87*	1.92	6.73*	2.94
Speaking	5.67	1.40	2.33*	1.63	7.33*	3.81
Writing	6.33	2.16	3.13*	3.27	7.87*	3.68
Writing-speaking	7.00	2.24	3.40	2.32	9.07	3.92
No-learning	5.87	1.30	4.53	1.64	11.40	2.97

* significantly different from no-learning group ($p < .05$)

In order to determine whether the four learning groups differed from each other, a series of analyses of variance was performed. These are presented in Table 10, Appendix A. The analyses show no significant differences among the four groups on any of the tests. These data offer no support for the hypothesis that overt responses enhance automated learning. The fact that the writing-speaking group did not differ significantly from the no-learning group after having been exposed to the program suggests that overt responses may be detrimental if overemphasized.

Findings of this sort call into question the place of the response in programmed learning. What purpose does the response serve? Apparently the feedback properties of the response per se play little or no role in automated learning. If feedback were important, we would expect writing, speaking, and/or both to have some advantage and in the context of this experiment they did not have any advantage. If the feedback properties of the response are not important, perhaps the function of the response is to insure attention. In that case covert responses would be just as effective as overt responses, provided that the S diligently makes the covert responses. Forcing the S to make an overt response simply insures that the techniques of behavior control

are operating effectively. While responses may help automated learning by forcing the student to attend to each item, there is still the question of whether the response is necessary for learning. This is an issue which requires clarification, since there are studies which indicate that the to-be-filled-in blanks in the programmed items may not be necessary. All that may be necessary is the "silent reading" of the items in proper sequence.

Kormondy (1959) found that a sequenced textbook with no blanks was as effective as a sequenced workbook containing blanks. Goldbeck (1960) reports that a "reading" response condition (no blanks) produced more efficient learning than an overt response condition. Learning efficiency was defined by dividing examination scores by learning time. Goldbeck also found that the "reading" response condition produced the best learning scores when the material to be learned was easy. It should be pointed out that Goldbeck used "discrete discourse" material in which each frame dealt with an independent unit of information. This is in contrast to the continuous discourse material used in typical teaching machine programs. The above findings are provocative, especially in view of Holland's findings (1960) that requiring the S to make a response is an important ingredient in programmed learning, providing the responses insure careful reading of the items. These studies suggest the need to pay further attention to the role of the response. Experiments IIA and IIB are concerned with the question of the response in programmed learning.

EXPERIMENT IIA

PROBLEM

The purpose of Experiment IIA was to determine whether requiring Ss to make responses of the constructed type is necessary for programmed learning. The findings reported by Kormondy (1959) and by Goldbeck (1960) suggest that such responses may not be necessary.

A comparison between response and no-response was made (a) under standard teaching machine conditions in which the Ss were unpaced, and (b) under a paced condition in which the Ss were exposed to each item for a similar period of time. If the purpose of the response is to insure careful reading of the items, we would expect greater differences between response and no-response under conditions where Ss are allowed to proceed at their own pace. Under the paced condition each S had ample time to read the items carefully; the pacing was designed to permit the Ss to attend to each item.

METHOD

THE EXPERIMENTAL SAMPLE

The Ss were 60 students drawn from the same subject pool used in Experiment I. The selection of Ss was based on the same criteria used in the first experiment. A total of 70 Ss was screened to obtain the experimental sample.

MATERIALS

The teaching machine and the pacing device were the same as those used in Experiment I.

The learning material was the basic electricity program. For one-half of the Ss the program was the same one used in Experiment I. For the other half of the Ss the items contained no blanks, that is, no missing word or words. A sample of these items is presented in Appendix B. The criterion test was the same one used in Experiment I.

PROCEDURE

The preliminary test was used to screen the Ss. The Ss selected to participate were assigned at random to one of four groups. Two of the groups were paced during learning at the same rates used in the first experiment. Two groups were not paced. One-half of the Ss in the paced group was instructed to write their responses.[1] Their instructions are presented in Appendix A (writing group). The remaining Ss in the paced group used the program containing no blanks. The instructions for this group are presented in Appendix B (paced--no-response group). One-half of the Ss in the unpaced group was instructed to write their responses. The instructions are presented in Appendix B (unpaced-response group). The remaining Ss were given the no-response instructions shown in Appendix B (unpaced--no-response group). Thus, this study was a 2 x 2 factorial design with pacing as one variable and response, no-response as another variable.

RESULTS AND DISCUSSION

The means and SDs for the preliminary test, the fill-ins test, and the total test are shown in Table 2. The analysis of variance for these data is presented in Table 11, Appendix B. Table 2 and the statistical analyses show that all four groups were similar prior to learning. Following the learning period the no-response groups made fewer errors on the fill-ins test than did the response groups ($p < .05$). The pacing groups made more errors than did the unpaced groups, but the differences were not significant and there were no interaction effects. The total test scores failed to reveal any significant differences.

1. The paced-response group is actually the writing group of Experiment I. The data for Experiments I and IIA were gathered concurrently.

Table 2

Means and SDs for the Preliminary, Fill-ins, and Total Test Error Scores for Experiment IIA
N = 15 for Each Group

		Preliminary Test		Fill-ins Test		Total Test	
		Paced	Unpaced	Paced	Unpaced	Paced	Unpaced
Response	Mean	6.33	5.20	3.13	2.40	7.87	6.20
	SD	2.16	1.08	1.81	1.84	3.68	3.08
No-response	Mean	5.73	5.67	2.07	1.53	6.27	5.93
	SD	2.09	1.23	1.67	1.24	2.74	2.79

These findings are similar to those of Kormondy (1959) and Goldbeck (1960), in that the Ss who were required to construct a response performed no better than the Ss who made no constructed response. In fact, the no-response Ss gave evidence of superior learning on the fill-ins test. Their superior performance was evident for the paced as well as for the unpaced conditions.

The results of this study suggest that the place of the constructed response in programmed learning is an important issue and deserves more attention. Because of the importance of this issue, a third study dealing with the response variable was performed. This study is reported below as Experiment IIB.

EXPERIMENT IIB

PROBLEM

The purpose of Experiment IIB was to compare the response and no-response conditions, using unfamiliar learning material and using the programmed text format in addition to the machine format. It was reasoned that the constructed response might prove to be more important in the programmed text format than in the machine format. With the programmed text, the S's attention is not as easily focused on each item; there is the constant temptation to look ahead or back and thus be distracted. If responses are required in order to insure careful attention, such insurance should be more important when the programmed text is used than when a machine is used, since the machine presents only one item at a time. This line of reasoning leads to the prediction that requiring responses would enhance programmed learning when the programmed text is used, but would have little or no effect when a machine is used.

The results of Experiments I and IIA suggest an alternative prediction: if we suppose that the constructed responses can be superfluous, even

distracting, then we might expect that requiring such responses might impair learning when the learning task is well defined and when there is little to distract the S from his task. This alternative position would lead to the prediction that the no-response condition would lead to better learning than a response condition when a machine is used and that learning would be comparatively equal when the programmed text is used.

METHOD

THE EXPERIMENTAL SAMPLE

The Ss were 62 students drawn from the elementary psychology classes in the University College of Arts and Science and the College of Engineering of New York University. The Ss were selected at random from a group of students who were given the option of participating in psychology experiments or writing a term report. These Ss were not paid. A total of 60 Ss participated in the experiment proper. Two Ss were dropped because the screening quiz given at the outset of the study showed that they were familiar with the learning materials.

MATERIALS

A programmed booklet and a simple spool type teaching machine were used. The programmed booklet is simply a series of pages on which are printed from six to ten items (see Appendix C). Cardboard frames were used to cover the answers and to frame the item being read. The frame contained a flap which the student was instructed to lift when he was ready to look at the correct answer. The spool machine was a 9 1/2 inch by 5 inch by 3 inch plastic box with a window in which the items were presented.[2] The program was printed on two rolls of paper, 45 items to each roll. The roll was attached to the spool in much the same way that a camera film is loaded and the drive mechanism was similar to that of a camera's. The drive mechanism permitted the S to move the program in one direction only. It prevented the S from going back to previous items.

The learning material consisted of a 90-item program in binary numbers. The entire program is presented in Appendix C. The criterion test was a 21-item examination, a sample of which is presented in Appendix C.

PROCEDURE

Each S was given a four-item preliminary screening quiz (Appendix C). The Ss who were able to answer all four items correctly were not used in the experiment. One-half of the Ss selected was assigned at random to a machine group and the other half was assigned to a booklet group. Half of the Ss in the machine group was given a standard program containing the usual blanks. The Ss were instructed to write their answers on a separate answer sheet (see Appendix C). The other half of the Ss in the machine group was given a program containing no blanks within the items and was instructed simply to read the items as they appeared in the window of the machine (see Appendix C).

---

2. This machine is made by the National Blank Book Company, Holyoke, Mass.

The booklet group was divided in the same way into a response (blanks) and a no-response (no blanks) group (instructions for the two groups are presented in Appendix C). Thus there were four groups of 15 Ss each; the groups differed with respect to the use of machine or booklet and with respect to the response, no-response conditions. In both the machine and booklet conditions the Ss proceeded at their own pace.

It should be noted that the Ss in the machine groups were interrupted after they had completed 45 items so that the experimenter could change the roll and insert the roll containing the next 45 items. This interruption took approximately one minute.

RESULTS AND DISCUSSION

The means and SDs of the error scores for Experiment IIB are presented in Table 3. An analysis of variance of these data (Table 12, Appendix C) indicated that there were no significant differences among the conditions. The overall differences between machine and booklet and between response (blanks) and no-response (no blanks) did not approach significance. The one set of differences that did approach statistical significance was the difference between response and no-response under machine learning conditions ($t = 1.60$, $df = 28$; $p < .15$)

Table 3

Means and SDs of Final Examination Error Scores for Experiment IIB
N = 15 for Each Group

	Response		No-response	
	Mean	SD	Mean	SD
Booklet	7.20	3.39	7.53	4.93
Machine	7.73	3.99	5.13	4.87

The results of this study do not actually confirm either of the predictions made above. However, more support is given to the prediction which is based on the supposition that constructed responses are superfluous when machines are used. The no-response condition did tend to produce better learning under the machine condition (the difference between response and no-response was 2.60 and the standard error of the difference was 1.60). With the booklet the two means were almost identical (the difference was .33 and the standard error was 1.54).

In Experiment IIA a statistically significant difference between the response and no-response condition under machine learning conditions was found. The fact that the difference was not as clear in Experiment IIB may have been due to the different subject matter. All indications were that the binary number program used in IIB was more novel than the electricity program used in

IIA, although not necessarily more difficult. The somewhat esoteric nature of the binary number program may have made it more attention-provoking, thus overriding some of the effects produced by the constructing of responses.

The fact that constructing responses did not benefit learning in either format is noteworthy in itself, in view of the many claims for the principle of requiring responses in programmed learning. The data of Experiments IIA and IIB demonstrate that the importance of the constructed response in programmed learning remains to be established. At this point all signs point to the importance of the items per se and not to the constructed responses which the items may force the learner to make.

When the learner does not make constructed responses, he apparently does not receive reinforcement in the form of seeing the correct answer. There is, in fact, no correct answer, for he is simply reading the items. Does this imply that he is not being reinforced? While initially we felt that one could say the Ss were not being reinforced on each frame (Silverman & Alter, 1960), we have since eschewed that position in favor of the position that Ss may be reinforced by each succeeding item. Since the programs are actually a series of progressive approximations, the S is reinforced for reading item 1 by his being able to read and comprehend item 2, and he is reinforced for a careful reading of item 2 by his comprehension of item 3, and so forth. In other words, we are hypothesizing that the Ss are reinforced by making progress. This position is essentially not different from Skinner's (1958).

EXPERIMENT III

PROBLEM

The purpose of Experiment III was to investigate the relative effectiveness of paced and unpaced programs presented on teaching machines. Descriptions of automated teaching devices invariably include some reference to the fact that Ss are able to proceed at their own rate. Unquestionably this has obvious advantages, but it does not necessarily follow that automated teaching depends at all or in part on this self-pacing feature. Briggs, Plashinski, and Jones (1959) found no differences between Ss who were self-paced and those who were machine-paced when the learning task was a 20 item paired-associate list. It should be noted, however, that paired-associate lists differ from the continuous discourse material used in teaching machine programs.

This experiment was designed to compare programmed learning under paced and unpaced conditions.

METHOD

THE EXPERIMENTAL SAMPLE

The Ss were 45 students selected by the same methods and from the same pool used in Experiments I and IIA.[3]

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3. Experiment III was performed concurrently with I and IIA.

MATERIALS

The materials were the same as those used in Experiment I.

PROCEDURE

The general procedure was the same as that described in Experiment I. The Ss were assigned at random to one of three groups. One group was paced according to the following schedule: 20 secs. per item for the first disk and 35 secs. per item for the second and third disks. This group is referred to as the paced group.[4] A second group was paced as follows: 30 secs. per item for the first disk and 50 secs. per item for the second and third disks. This group is called the long-paced group. A third group was not paced and is referred to as the unpaced group.

RESULTS AND DISCUSSION

The results of the preliminary tests, the fill-ins tests, and the total tests are presented in Table 4. The statistical analyses of these data are presented in Tables 13 and 14, Appendix D.

The analysis of variance of the preliminary tests was significant ($p < .05$), indicating that the groups differed before the experimental conditions were imposed. To control for these pre-experimental differences, the means of the criterion tests were adjusted in terms of the preliminary test means and analysis of covariance was performed. The analysis of covariance reveals no significant differences among the three experimental conditions. The unpaced group does not differ from the paced groups, nor do the paced groups differ from each other. It should be noted that all three groups show evidence of learning ($p < .05$) when compared to the no-learning group described in Experiment I.

Table 4

Means and SDs of the Preliminary, Fill-ins, and Total Test Error Scores for Experiment III
N =15 for Each Group

	Preliminary		Fill-ins		Total	
	Mean	SD	Mean	SD	Mean	SD
Paced	6.33	2.16	3.13	1.81	7.67	3.68
Long-paced	7.00	2.33	2.67	1.59	7.60	3.29
Unpaced	5.20	1.08	2.40	1.84	6.20	3.08

4. This group is the writing group of Experiment I.

The restriction imposed by pacing did not hamper nor did it enhance learning. The Ss in the long-paced group did complain about boredom, but their learning scores showed no evidence of deterioration. It is obvious that the extent to which pacing might affect learning depends in part on the speed of the pacing. In this experiment the paced group proceeded at what is believed to be close to an optimum rate of presentation. The time allowed each item was congenial to most Ss as determined by preliminary testing for an optimum presentation rate; if the time had been shortened, some Ss would have been placed at a disadvantage.

EXPERIMENT IV

PROBLEM

The purpose of Experiment IV was to investigate the motivational properties of two teaching machines. There has been much speculation about the possible role of novelty in the use of teaching machines. References are made to the "pinball machine effect" and the "hardware effect" of the machines themselves. It is sometimes suggested that these effects may temporarily influence learning and thus give a false picture of the effectiveness of automated teaching.

This study involved comparisons among two automated devices, an elaborate electromechanical machine and a crude (in appearance) wooden-cased mechanical machine, and a programmed textbook. The study was also designed to examine novelty effects by comparing the first or novel exposure to a device (includes booklet) with the second or familiar exposure to the same device. If novelty effects were operating, we would expect the second exposure to elicit a level of performance different from that elicited by the first exposure.

METHOD

THE EXPERIMENTAL SAMPLE

The Ss were paid volunteers ($1.50 per hour) selected from a pool of summer session students at the University College of Arts and Science and the College of Engineering of New York University, and from the summer session of the William Howard Taft High School, New York City. A total of 115 Ss participated in some phase of the experiment, but only 60 Ss took part in the full experiment (30 college students and 30 high school students). The Ss who participated in the full experiment were selected on the basis of a three-question preliminary quiz in psychology (Appendix E) or a four-question quiz on binary numbers (Appendix C), and on their ability to go through the initial program (psychology or binary numbers) while making less than 30% errors. Of the Ss who did not participate in the full experiment, 8 were too well informed, as indicated on the screening quiz; 20 made more than 30% errors on the initial program; 7 failed to return for a second experimental session, and 20 were discarded because of equipment failure.

MATERIALS

Two teaching machines and a programmed booklet were used. The programmed booklet is described in Experiment IIB. One of the teaching machines was an elaborate electromechanical device, the Multiple Sensory Stimulation Trainer (Device X-11-H-20) supplied by the U. S. Naval Training Device Center. This device is described in more detail in Appendix E. In this study the above device is referred to as the elaborate machine. The other teaching machine, referred to as the crude machine, was a spool-type device encased in an 18 inch by 16 inch by 7 inch wooden cabinet. The machine was constructed so as to appear crude. However, in terms of presenting the programs it functioned as well as the elaborate machine. A brief description of the crude machine is given in the instructions section in Appendix E.

The teaching materials consisted of two 90-item programs: one was the binary number program used in Experiment IIA (Appendix C). The other program was a part of the Holland program in psychology (1959). The first 84 items were taken directly from the Holland program; the last 6 items were written by the authors so as to round out a unit of learning material on which a student could be tested. A sample of the items from the psychology program is presented in Appendix E.

The criterion tests were 21-item examinations. The binary number examination is presented in Appendix C and the psychology examination is presented in Appendix E.

PROCEDURE

The Ss were screened on the basis of the preliminary tests. The Ss who obtained perfect scores (four correct in binary numbers, three correct in psychology) were eliminated from further participation. The experiment was conducted in two sessions held on the average of one week apart. In the first session the S was given one of the programs and in the second session he was given the other. The program order was counterbalanced so that one-half of the Ss took psychology first and one-half took binary numbers first. Each S learned on the same machine or the booklet during the two sessions. At the end of the first session the S was given an appointment for a second session. The second session ranged from three to thirteen days later, with a mean of seven days. The high school students were assigned at random to one of three groups: one group used the elaborate machine; one group used the crude machine, and one used the booklet. One-half of the Ss in each group worked through the psychology program in the first session and the binary number program in the second session. The remaining Ss worked through the programs in the opposite order. The college students were assigned to groups in a similar manner. Thus, there were three dimensions in this experiment: (1) machine type, (2) session, and (3) educational level. The experiment was a 2 x 2 x 3 factorial design, with the session's dimension representing two measurements of the same S. The instructions given to the Ss in the two machine conditions and the programmed booklet condition are presented in Appendix E.

RESULTS AND DISCUSSION

In order to determine whether there were systematic differences among the groups with respect to the number of days between sessions, an analysis of

the days was made. The data on which the analysis was based are presented in Table 15, Appendix E, and the analysis of variance is presented in Table 16, Appendix E. The two tables reveal that the difference between the orders of presenting the program was significant. The time (days) elapsed between the groups who were given the binary program first and the psychology program second was, on the average, longer than the groups who were given the psychology program first. This was the only significant difference found and is itself not important, since order of presentation was not an experimental condition. The two orders were combined for all the statistical analyses relating to the experimental conditions.

Before testing the experimental hypotheses it was necessary to transform the criterion test raw data so as to permit comparisons between sessions. All raw scores were transformed into T scores, with a mean of 50 and an SD of 10. The statistical analyses were performed on these T scores. A relatively high T score indicates good performance and a low score indicates poor performance.

The means and SDs of the T scores for all conditions are presented in Table 5. Table 6 shows a summary of the devices (machines and booklet) and sessions. Table 7 shows a summary of devices and educational level. The statistical analyses of the data in these tables is presented in Table 17, Appendix E. Table 8 presents a summary of devices and program. The statistical analysis of the data in Table 8 is shown in Table 17, Appendix E.

These tables reveal only one significant difference: the difference between educational level is significant ($p < .01$). The college students achieve higher scores than the high school students on all three devices (note Table 7). The differences among devices are not significant. The Ss' performance on the devices in both sessions (Table 6), for both educational levels (Table 7), and for both courses (Table 8), is generally equivalent. No significant differences between sessions were found; the Ss perform equally well in session I and session II.

Thus, this experiment provides no support for concluding that machines have motivational properties. In terms of the machines used here, it made little difference whether Ss learned on an elaborate machine or a programmed booklet. From session to session there was little or no change in performance and consequently no evidence of waning interest and novelty effects.

It should be pointed out that novelty effects might have been operating in the programs. It is possible that the machines may have provided some novelty which diminished from the first to the second session, only to be replaced by the novelty of a new program. If the programs did elicit novelty effects, they could have maintained a sufficiently high level of interest to prevent a drop in performance during the second session. A better test of novelty effects should involve the use of only one program so as to keep the program variable from confounding machine effects.

Table 5

Means and SDs of T Scores for all the Conditions of Experiment IV
N =10 for Each Group

		Elaborate		Crude		Booklet	
		Coll.	H. S.	Coll.	H. S.	Coll.	H. S.
Session I	Mean	54.14	45.58	54.67	47.44	52.71	45.83
	SD	7.76	6.53	10.59	7.17	8.80	11.05
Session II	Mean	52.88	51.10	56.07	46.25	52.35	40.01
	SD	10.47	10.39	7.59	8.08	8.99	7.91

Table 6

Summary Comparing Devices and Session: Means and SDs of T Scores
N =20 for Each Group

		Elaborate	Crude	Booklet
Session I	Mean	49.86	51.06	49.27
	SD	8.25	9.55	10.34
Session II	Mean	51.99	51.16	46.18
	SD	10.19	9.14	10.35

Table 7

Summary Comparing Devices and Educational Level:
Means and SDs of T Scores

N = 10 for Each Group

		Elaborate	Crude	Booklet
College	Mean	53.51	55.37	52.53
	SD	8.99	8.99	8.66
High School	Mean	48.34	46.84	42.92
	SD	8.91	7.47	9.82

Table 8

Summary Comparing Devices and Programs:
Means and SDs of T Scores

N = 20 for Each Group

		Elaborate	Crude	Booklet
Psychology	Mean	50.46	50.34	48.97
	SD	9.89	9.24	10.42
Binary Numbers	Mean	51.40	51.88	46.48
	SD	8.71	9.39	10.41

A further source of confounding in studies like this one is the ever present "Hawthorne" effect (Kitson, 1922). It should be noted that the Ss' motivation appears to be strong. They showed considerable interest in the technique and generally impressed the experimenter with their desire to return to serve again in studies of this sort. It would seem that more than two experimental sittings may be required to lessen this effect and to produce a more refined test of the hypotheses dealing with the motivational properties of automated teaching.

The clear differences in achievement between the college and high school students indicate that the programs used here were not refined to the point where they were free of intelligence and prior achievement effects. It would be extremely difficult to write programs for adults that did not make use of their prior reading and attention skills. It would be interesting to compare achievement scores of a similar sample of college and high school students after they had been exposed to the conventional teaching of psychology and binary numbers. We might find more extreme differences in accomplishment with the college students being far superior to the high school students. With the programmed technique used here, the college students were better, but not to an extreme degree.

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APPENDIX A

Sample of Electricity Program

1. Matter is composed of small particles called molecules which, in turn, are composed of even smaller particles, atoms. A molecule of water is composed of two atoms of hydrogen and one_____ of oxygen.

2. An atom consists of a nucleus and electrons. The nucleus contains protons which are positively charged, and neutrons which have no charge. The net charge is thus_____ .

3. Since the atom is usually electrically neutral and the nucleus has a positive charge, you might guess that the electrons have a _____ charge.

4. If the positive charge on the proton equals the negative charge on the electron, you would expect that the number of protons_____ the number of electrons, rendering the atom electrically neutral.

5. Like charges repel; unlike charges attract. An electron, thus, will _____ another electron. It will be _____ by a positively charged atom.

6. Electrons revolve around the nucleus in orbits or rings. The further away from the _____, the easier it is to separate an electron from an atom.

7. A balanced atom has an equal number of protons and _____ and is electrically neutral.

8. If an atom gains electrons it becomes negatively charged. If it loses electrons it becomes _____ charged.

9. It requires very little energy to free _____ in the outer orbits. The removal of electrons leaves an atom positively charged.

10. The movement or flow of free electrons gives rise to an electric current. A substance composed of atoms whose electrons are readily _____ is known as a conductor of electricity.

APPENDIX A

Preliminary Test: Basic Electricity

This is a preliminary test. Even if you feel you do not have the slightest idea as to what the answer to a question is, choose one of the four alternatives. EVERY QUESTION MUST BE ANSWERED. Please print your answers ON THE ANSWER PAPER.

DO NOT WRITE ON THIS SHEET

1. An atom is composed of
   a. protons and neutrons
   b. electrons and protons
   c. electrons, protons and neutrons
   d. neutrons, electrons, and a nucleus

2. The basic negative electric charge is known as the
   a. neutron
   b. diode
   c. electron
   d. proton

3. An atom which has gained electrons is
   a. positively charged
   b. negatively charged
   c. uncharged
   d. the same electrically as it was before

4. A flow of electric current is considered to be a flow of
   a. free neutrons
   b. bound electrons
   c. free protons
   d. free electrons

5. An atom or group of atoms which has become charged is called a(n)
   a. molecule
   b. ion
   c. anode
   d. nucleus

6. A conductor differs from an insulator in that a conductor
   a. possesses only balanced atoms
   b. does not retain electrons easily
   c. retains electrons firmly
   d. possesses extremely high resistance

7. The rule applying to electric charges is
   a. unlike charges repel; like charges attract
   b. like charges can neither repel nor attract
   c. negative charges repel; positive charges attract
   d. like charges repel; unlike charges attract

APPENDIX A

DO NOT WRITE ON THIS SHEET

8. If the outer ring of electrons in an atom has more than half its complete capacity it will tend to
   a. lose them to another atom
   b. gain the remainder from another atom
   c. remain as it is if the number of electrons is over five
   d. remain as it is because electrons cannot be separated from an atom

9. The unit for electromotive force is the
   a. ohm
   b. ampere
   c. volt
   d. watt

STOP! Give ME your answer sheet RIGHT NOW!! Do not continue until you are told to c
You may now continue with the next set of questions; use another answer sheet.

10. A parallel circuit is one in which current can
    a. flow through more than one path
    b. flow through only one path
    c. flow parallel to the magnetic field it induces
    d. flow through resistors which are parallel to the source

11. The _____ is the same in all parts of a series circuit
    a. electrolysis
    b. current
    c. voltage
    d. heat generated

12. Ohm's Law may be stated as follows:

    a. $I = E/R$

    b. $R_t = R_1 + R_2$

    c. $W = I^2R$

    d. $E = W/I$

13. A length of wire used in a circuit has a resistance of 10 ohms. If this wire were replaced by another of the same material and length but with a cross section only half as great, the resistance would be
    a. 5 ohms
    b. 20 ohms
    c. 12.5 ohms
    d. 7.5 ohms

14. In a parallel circuit the total resistance is
    a. the sum of the individual resistances
    b. the average of the individual resistances

DO NOT WRITE ON THIS SHEET

c. less than the resistance of any one of the resistors
d. proportional to the applied voltage

15. How much current will flow through a 15-ohm waffle iron on a 120-volt line?
    a. 1800 amps
    b. 8 watts
    c. 1800 watts
    d. 8 amps

16. A 15 ohm resistance is put in series with a parallel unit consisting of one 30-ohm and one 10-ohm resistor. What is the total resistance?
    a. 55.00 ohms
    b. 22.50 ohms
    c. 15.13 ohms
    d. 5.00 ohms

17. If a 10-ohm and a 20-ohm device are in parallel on a 120-volt line, the current flowing through each, respectively, is
    a. 1200 and 2400 amps
    b. 6 and 12 watts
    c. 2400 and 1200 watts
    d. 12 and 6 amps

APPENDIX A

Final Test: Basic Electricity

Answer ALL the questions. Print your answers on your answer sheet.
DO NOT WRITE ON THIS PAPER

1. The nucleus of an atom has a _____ charge.

2. The most stable arrangement in an atom is one in which
   a. the number of protons and neutrons is equal
   b. the number of protons and electrons is equal
   c. the outer ring of protons is complete
   d. the outer ring of electrons is complete

3. A substance is considered a conductor when it
   a. possesses only balanced atoms
   b. does not retain electrons readily
   c. retains electrons firmly
   d. possesses extremely high resistance

4. A 100 foot length of wire that is used in a circuit has a resistance of 5 ohms. It is found necessary to add wire of exactly the same type to make the resistance of the circuit 20 ohms. How much wire will have to be added to the 100 foot length?

5. A length of wire used in a circuit has a resistance of 10 ohms. If this wire were replaced by another of the same material but with a cross section only half as great, the resistance would be _____ ohms.

6. The ampere is a measure of
   a. the number of units of charge flowing past a given point
   b. the number of units of charge flowing past a given point per given time
   c. the force with which each unit of charge flows past a given point
   d. the total number of units of charge which flowed in the circuit during the time a difference of potential was applied

7. Ohms Law states _____ (give equation in symbols or words).

8. To maintain a constant current in a device in which the voltage is constantly dropping we must (increase/decrease) _____ the resistance as the voltage decreases.

9. A series circuit differs from a parallel circuit in that
   (1) in a series circuit the current can take only one path
   (2) in a series circuit the current can take more than one path
   (3) a series circuit resists the flow of current less than a parallel circuit
   (4) a series circuit resists the flow of current more than a parallel circuit

DO NOT WRITE ON THIS SHEET

a. (1) and (3)
b. (2) and (4)
c. (2) only
d. (1) only

10. According to the definition you learned, to which of the following would the term "load" apply?
    a. the resistance of the metal wires comprising the circuit
    b. a radio
    c. the force of voltage applied to set the electrons in motion
    d. a generator or source of emf

11. The _____ is the same in all parts of a series circuit.
    a. resistance
    b. voltage
    c. current
    d. conductance

12. In a series circuit consisting of 3 resistors, a 5 ohm, a 10 ohm, and a 20 ohm, the combined resistance is
    a. 2.86 ohms
    b. the average of the three, 11.67 ohms
    c. the sum of the three, 35.00 ohms
    d. 20.0 ohms

13. If a 30 ohm toaster is powered by a 120 volt source, how much current is flowing through it?

14. Two resistors are wired in series with a 120-volt source. One resistor, A, has twice the resistance of the other, B. Their combined resistance is 20 ohms. Which statement is true?
    a. the total current flowing in the circuit is 1/6 ampere
    b. twice as much current flows through B as A
    c. 3 amp flows through each of the resistors; total current is 6 amp
    d. 6 amp flows through each of the resistors; total current is 6 amp

15. The combined resistance of several 4 ohm resistors in parallel is
    a. less than 4 ohms
    b. more than 4 ohms
    c. 4 ohms
    d. depends on the applied voltage

16. A switch used in house lighting would have to be connected in (series/parallel) _____ with the light it controls.

17. If a 5-ohm wire and a 10-ohm wire are connected in parallel, the 5-ohm wire will carry

DO NOT WRITE ON THIS SHEET

a. half as much current as the other
b. twice as much current as the other
c. the same amount of current as the other
d. $\left(\frac{1}{5} + \frac{1}{10}\right)$ times as much current as the other

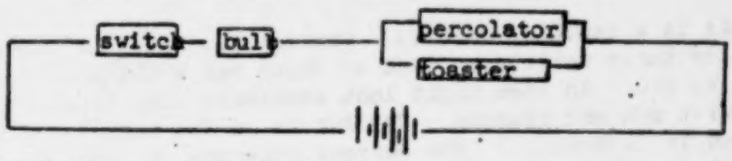
18. Write out the mathematical relation between the total resistance of three resistors, R_1, R_2, and R_3 in parallel, and the resistance of each of the three resistors.

19. A 10-ohm and a 20-ohm resistor are connected in series. The applied voltage is 120 volts. Which of the following is true?
    a. the voltage drop across the 10-ohm resistor is twice the voltage drop across the 20-ohm resistor
    b. the voltage drop is the same across both resistors and sums up to 120 volts
    c. the voltage drop across each of the resistors is 120 volts
    d. the voltage drop across the 20-ohm resistor is twice the drop across the 10-ohm resistor

20. A 15-ohm toaster, a 10-ohm heater, and a 10-ohm percolator are connected in parallel to a 120-volt line. The current flowing through each device is _____, _____, and _____, respectively.

21. Most household devices are wired in parallel because
    a. they can then operate independently of one another
    b. this decreases the total resistance thus lowering the voltage needed to push current through the devices
    c. the voltage is then the same for all devices, making it easier to buy standard items
    d. the total resistance is maximized in this way, thus permitting less current to flow. This reduces the risk of "burning out" the devices due to an oversupply of current

22. A 1-ohm switch and a 3-ohm light bulb are connected in series with a 10-ohm toaster and a 15-ohm percolator. The toaster and percolator are in parallel with one another. The applied voltage is 120 volts.



The total resistance of the circuit is_____.
The total current flowing through the circuit is_____.

Please: do not discuss this experiment. It is important that subjects do not have advance information.

APPENDIX A

Instructions to Covert Response Group

This is a teaching machine. The material will be presented to you in units of two or three sentences, each of which has a blank or blanks in it to be filled in by you. An item might look something like this: "The solar system is composed of a sun and planets. The sun is at the center and the _____ revolve around it in orbits." The correct response, of course, is "planets." Bringing the lever straight up will reveal the correct answer. Bringing it down will advance the machine to the next item.

After reading the item you are to think the word or words to fill in the blanks. In the above example you would think the word "planets." Then raise the lever to reveal the correct answer and compare it with yours. Your "mode of response" is implicit.

When you have made your response and compared it with the correct response, advance the machine to the next item by lowering the lever. When you return to the beginning of the material (where it says "Write your subject number...") call me in to change the disk. At the end of three disks you will be given a written quiz.

You will be paced by a timer which will sound at fixed intervals of time. Each time the timer sounds you should move to the next item by lowering the lever. In the interval you will have to read the item, make your response, and compare it with the correct response. If you have time left over, continue to look at the item. Wait till the timer sounds before advancing. The purpose of this is to ensure that each subject has equal exposure time on each item. Please bear this in mind if the equipment should jam. If necessary, avoid looking at an item until the next pacing signal.

You may have seen or even studied some parts of this material at some time. If this is so, please try, for this experiment, to forget what you learned previously. Our previous data show that subjects who try to apply what they already know tend to make incorrect responses because they are not following the train of thought of this material.

Instructions to Writing Group

This is a teaching machine. The material will be presented to you in units of two or three sentences, each of which has a blank or blanks in it to be filled in by you. An item might look something like this: "The solar system is composed of a sun and planets. The sun is at the center and the _____ revolve around it in orbits." The correct response, of course, is "planets." Bringing the lever straight up will reveal the correct answer. Bringing it down will advance the machine to the next item.

You are to write your responses on the paper in the right-hand slot after reading the item. Then raise the lever to reveal the answer and compare

yours with it. Your "mode of response" is written.

When you have made your response and compared it with the correct response, advance the machine to the next item by lowering the lever. When you return to the beginning of the material (where it says "Write your subject number...") call me in to change the disk. At the end of three disks you will be given a written quiz.

You will be paced by a timer which will sound at fixed intervals of time. Each time the timer sounds you should move to the next item by lowering the lever. In the interval you will have to read the item, make your response, and compare it with the correct response. If you have time left over, continue to look at the item. Wait till the timer sounds before advancing. The purpose of this is to ensure that each subject has equal exposure time on each item. Please bear this in mind if the equipment should jam. If necessary, avoid looking at an item until the next pacing signal.

You may have seen or even studied some parts of this material at some time. If this is so, please try, for this experiment, to forget what you learned previously. Our previous data show that subjects who try to apply what they already know tend to make incorrect responses because they are not following the train of thought of this material.

Instructions to Speaking Group

This is a teaching machine. The material will be presented to you in units of two or three sentences, each of which has a blank or blanks in it to be filled in by you. An item might look something like this: "The solar system is composed of a sun and planets. The sun is at the center and the _____ revolve around it in orbits." The correct response, of course, is "planets." Bringing the lever straight up will reveal the correct answer. Bringing it down will advance the machine to the next item.

After reading the item you are to speak your response. Speak so that you will not disturb the subject in the next booth, but speak! In the above example you would have said "planets." Then raise the lever to reveal the answer and compare it with yours. Your "mode of response" is spoken.

When you have made your response and compared it with the correct response, advance the machine to the next item by lowering the lever. When you return to the beginning of the material (where it says "Write your subject number...") call me in to change the disk. At the end of three disks you will be given a written quiz.

You will be paced by a timer which will sound at fixed intervals of time. Each time the timer sounds you should move to the next item by lowering the lever. In the interval you will have to read the item, make your response, and compare it with the correct response. If you have time left over, continue to look at the item. Wait till the timer sounds before advancing.

APPENDIX A

The purpose of this is to ensure that each subject has equal exposure time on each item. Please bear this in mind if the equipment should jam. If necessary, avoid looking at an item until the next pacing signal.

You may have seen or even studied some parts of this material at some time. If this is so, please try, for this experiment, to forget what you learned previously. Our previous data show that subjects who try to apply what they already know tend to make incorrect responses because they are not following the train of thought of this material.

Instructions to Writing-Speaking Group

This is a teaching machine. The material will be presented to you in units of two or three sentences, each of which has a blank or blanks in it to be filled in by you. An item might look something like this: "The solar system is composed of a sun and planets. The sun is at the center and the _____ revolve around it in orbits." The correct response, of course, is "planets." Bringing the lever straight up will reveal the correct answer. Bringing it down will advance the machine to the next item.

After reading the item you are to both speak and write your response. Speak so that you will not disturb the subject in the next booth, but speak! In the above example, you would have written and said "planets." Then raise the lever to reveal the correct answer and compare it with yours. Your "mode of response" is spoken and written.

When you have male your response and compared it with the correct response, advance the machine to the next item by lowering the lever. When you return to the beginning of the material (where it says "Write your subject number...") call me in to change the disk. At the end of three disks you will be given a written quiz.

You will be paced by a timer which will sound at fixed intervals of time. Each time the timer sounds you should move to the next item by lowering the lever. In the interval you will have to read the item, make your response, and compare it with the correct response. If you have time left over, continue to look at the item. Wait till the timer sounds before advancing. The purpose of this is to ensure that each subject has equal exposure time on each item. Please bear this in mind if the equipment should jam. If necessary, avoid looking at an item until the next pacing signal.

You may have seen or even studied some parts of this material at some time. If this is so, please try, for this experiment, to forget what you learned previously. Our previous data show that subjects who try to apply what they already know tend to make incorrect responses because they are not following the train of thought of this material.

APPENDIX A

Instructions to No-Learning Group

The topic we teach is basic electricity. Usually, after the preliminary exam our subjects spend between 30 and 45 minutes learning about electricity on teaching machines, and then they are given a final exam.

You are a member of a control group designed to give us some comparison information so that we may better evaluate the efficiency of teaching with machines. You will be given the preliminary exam, and then, without learning anything further about electricity, you will be given a final examination.

It is possible that the performance of many of our subjects on the final exam is the result, not of learning, but of recalling material that they used to know. To control for this we are going to give you a task which is designed to help you remember whatever you may know about electricity.

We will give you a list of words and ask you to write out whatever you know about each one. Realizing that you might regard this as an examination and become anxious about it, we decided to explain its purpose to you. Do not regard this as an exam... It is simply a device to ensure that you spend as much time "thinking" about electricity as the other subjects spend learning about it. It is designed solely to help you remember whatever you may know about electricity. You will be given a subject number and will remain anonymous.

APPENDIX A

List Given to No-Learning Group

Following is a list of terms, each of which has something to do with electricity. You may or may not have seen these terms before. I want to elicit as much information as you have about each of these terms. Define them if that is appropriate, and if you can, or write anything you know about them. Do not be too concerned about writing a beautiful essay. You can list whatever you remember in outline or in any other form you choose. Sometimes you may not be too sure but may think you have some information about a term. Guess. Write it down. Read through the entire list. Seeing some of the words may help you to remember something about the others.

It is not necessary to write something about every single term, although if you can, we hope you will. The experimenter will interrupt you at the end of one-half hour.

We use this sheet for all the subjects, so please write on the pad provided and not on this.

1. wall socket
2. plug
3. light bulb
4. filament
5. iron
6. toaster
7. electric wires
8. insulation
9. conductor
10. resistance
11. generator
12. kilowatt hours
13. watt
14. volt
15. atom
16. electron
17. proton
18. ion
19. positive
20. negative
21. battery
22. circuit
23. current flow
24. ohm
25. ampere
26. electromotive force
27. difference of potential
28. series circuit
29. parallel circuit
30. Ohm's law
31. resistance in series
32. resistance in parallel
33. current in a series circuit
34. voltage drop

APPENDIX A

Table 9

t Tests between No-learning Group and the Four Groups of Experiment I
N = 15 for Each Group

Group	Preliminary Test	Final Test Fill-ins	Final Test Total
Covert	0.84	2.59**	3.89**
Speaking	0.31	3.44**	3.39**
Writing	0.72	2.19*	2.94**
Writing-Speaking	1.77	1.77	1.94

* .05 level
** .01 level

Table 10

Analysis of Variance of Response Mode Data from Experiment I

		Preliminary		Fill-ins		Total	
Source	df	SS	F	SS	F	SS	F
Between groups	3	24.58	2.47	9.33	-	44.32	1.13
Within groups	56	186.00		210.40		728.93	
Total	59	210.58		219.73		773.25	

APPENDIX B

Sample of Basic Electricity Program, No-response

1. Matter is composed of small particles called molecules which, in turn, are composed of even smaller particles, atoms. A molecule of water is composed of two atoms of hydrogen and one atom of oxygen.

2. An atom consists of a nucleus and electrons. The nucleus contains protons which are positively charged, and neutrons which have no charge. The net charge is thus positive.

3. Since the atom is usually electrically neutral and the nucleus has a positive charge, you might guess that the electrons have a negative charge.

4. If the positive charge on the proton equals the negative charge on the electron, you would expect that the number of protons equal the number of electrons, rendering the atom electrically neutral.

5. Like charges repel; unlike charges attract. An electron, thus, will repel another electron. It will be attracted by a positively charged atom.

6. Electrons revolve around the nucleus in orbits or rings. The further away from the nucleus, the easier it is to separate an electron from an atom.

7. A balanced atom has an equal number of protons and electrons and is electrically neutral.

8. If an atom gains electrons it becomes negatively charged. If it loses electrons it becomes positively charged.

9. It requires very little energy to free electrons in the outer orbits. The removal of electrons leaves an atom positively charged.

10. The movement or flow of free electrons gives rise to an electric current. A substance composed of atoms whose electrons are readily freed is known as a conductor of electricity.

APPENDIX B

Instructions to Paced--No-Response Group

This is a teaching machine. The material will be presented to you in units of two or three sentences each. An item might look something like this: "The solar system is composed of a sun and planets. The sun is at the center and the planets revolve around it in orbits."

Bringing the lever straight up and then straight down, briskly, will advance the machine to the next item.

You will be paced by a timer which sounds at fixed intervals of time. Read the item, and when the timer sounds, advance the machine to the next item by raising and then lowering the lever. When you return to the beginning of the material (where it says "Write your subject number...") call me in to change the disk. At the end of three disks you will be given a written quiz.

You may have seen, or even studied, some parts of this material at some time. If this is so, please try, for this experiment, to forget what you learned previously. Our previous data show that subjects who try to use what they already know tend to become confused because they are not following the train of thought of this material, and this impairs their performance on the final quiz.

Instructions to Unpaced-Writing Group

This is a teaching machine. The material will be presented to you in units of two or three sentences, each of which has a blank or blanks in it to be filled in by you. An item might look something like this: "The solar system is composed of a sun and planets. The sun is at the center and the _____ revolve around it in orbits." The correct response, of course, is "planets." Bringing the lever straight up will reveal the correct answer. Bringing it down will advance the machine to the next item.

You are to write your responses on the paper in the right-hand slot after reading the item. Then raise the lever to reveal the answer and compare yours with it. Your "mode of response" is written.

When you have made your response and compared it with the correct response, advance the machine to the next item by lowering the lever. When you return to the beginning of the material (where it says "Write your subject number...") call me in to change the disk. At the end of three disks you will be given a written quiz.

Work at your own speed. Do not rush, but do not dwell over each item unnecessarily. There will be no time limit. To give you some idea, most subjects get through these three disks in about 40 to 50 minutes.

You may have seen or even studied some parts of this material at some

time. If this is so, please try, for this experiment, to forget what you learned previously. Our previous data show that subjects who try to apply what they already know tend to make incorrect responses because they are not following the train of thought of this material.

Instructions to Unpaced--No-response Group

This is a teaching machine. The material will be presented to you in units of two or three sentences each. An item might look something like this: "The solar system is composed of a sun and planets. The sun is at the center and the planets revolve around it in orbits." Bringing the lever straight up and then straight down will advance the machine to the next item.

When you have read the item, advance the machine to the next item by raising and then lowering the lever. When you return to the beginning of the material (where it says "Write your subject number...") call me in to change the disk. At the end of three disks you will be given a written quiz.

You may have seen, or even studied some parts of this material at some time. If this is so, please try, for this experiment, to forget what you learned previously. Our previous data show that subjects who try to use what they already know tend to become confused because they are not following the train of thought of this material, and this impairs their performance on the final quiz.

IF THE MACHINE SHOULD SKIP OR JAM, CALL ME IN IMMEDIATELY.

Table 11

Analysis of Variance of Response--No-response and Paced-Unpaced Conditions from Experiment IIA

		Preliminary Test		Fill-ins Test		Total Test	
Source	df	SS	F	SS	F	SS	F
Response	1	.07	-	14.02	5.10*	13.07	1.37
Pacing	1	5.40	1.84	6.02	2.19	15.00	1.57
R x P	1	4.27	1.46	.15	-	6.67	-
Within Cells	56	164.00		154.00		536.00	
Total	59	173.74		174.19		570.74	

* .05 level

APPENDIX C

Binary Number Program

1. A digit is a symbol we use to indicate quantity. We use the symbol 6 to mean the quantity six. We use the symbol 9 to mean the quantity ___. — nine

2. It is possible to use other symbols. We use the digit 5 to represent the quantity five. The Romans used the symbol V to represent the quantity ____. — five

3. We use a "decimal" system which is based upon ten different symbols or, as we call them, digits. A digit is a _____ we use to indicate a given quantity. — symbol

4. The digit 6 represents the quantity six; the digit 4 represents the quantity four. The ten different digits we use each represents a different _____. — quantity

5. It is not necessary to use ten different_____ to indicate quantity. We might use only four or five different digits. — digits or symbols

6. In our system of numbering we use ten different symbols or digits, 0, 1, 2, 3, 4, 5, _, _, _, and _ to indicate quantities from nothing to nine. — 6, 7, 8, and 9

7. As you will learn later on, the symbol 10 (read "one oh") may represent quantities other than ten; for example, two, five, seven. In our system, the decimal system, 10 represents the quantity _____. — ten

8. From now on, when we are referring to a quantity we will write it out in words so that we can distinguish it from its symbol. — a) seventeen b) twenty

Decimal number	Quantity
10	ten
17	a)____
20	b)____

9. When we are referring to the numerical symbol for a given quantity, we will write the number, not the word.

Decimal number	Quantity
10	ten
a)___	seventeen
b)___	twenty-five

a) 17
b) 25

10. To reemphasize the difference between digits (or numbers) and quantities: 0, 1, 2, 3, etc. are a)___. Zero, one, two, three, etc. are the b)___ they represent.

a) digits or numbers
b) quantities

11. The mileage indicator on an automobile speedometer counts the number of miles we have traveled.

b	a

Column a counts in single miles, or one mile at a time. Column b counts by tens or ____ miles at a time.

ten

12. An indicator reading of

b	a
0	1

means we have traveled a)___ mile. An indicator reading of

b	a
1	0

(read "one oh") means we have traveled b)_____ miles.

a) one
b) ten

13.

b	a
	1

When we say column a represents single miles and column b "ten miles," we mean that a 1 in column a shows that we have traveled one mile. The same symbol, 1, in column b shows that we have gone 1 times ten or ____ miles.

b	a
1	0

ten

14.

b	a

In our system of numbering we can change the quantity that a digit represents by changing its position. For example, moving a 1 from column a to column b changes its value from one to _____.

ten

15. We apply the term "positional notation" to an arithmetic system in which we can change the quantity a digit represents by changing its _____.

position

16. We have already said that a mileage indicator _____ miles. We shall try to illustrate certain features of "counting" by using the mileage indicator as an example.

counts

17. b a
[ ][9]
When the number in column a is 9, we have traveled ____ miles. nine

18. b a
[0][9]
The highest number we have is 9, so the numbers in column a cannot go higher than that. This means column a cannot indicate more than ____ (quantity) miles. nine

19. Column b is the "ten mile" column. When the indicator reads b a [9][0] (read "nine oh") we have gone 9 times ten or ____ miles. ninety

20. When the indicator reads b a [0][9] (read "oh nine") and we go a mile farther, the digit 1 appears in column b and the numbers in column a start again at the digit ____. 0 (not zero)

21. b a
[1][0]
Column a cannot show more than nine miles. To show that we have gone ten miles, the digit ____ appears in column b and the numbers in column a begin again at 0. 1 (not one)

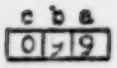
22. An indicator reading of b a [2][9] means that we have gone ____ miles, or 2 times ten plus 9 tin one. twenty-nine

23. b a
[2][9]
If we go one mile farther the numbers in column a will start again at the digit____ ani column b will be increased by the quantity ____. 0, one

24. If the indicator reads b a [4][9] and we go one mile farther, the numbers in column a will begin again at 0 and column b will be ____ by one. increased

25. An indicator reading of b a [9][9] means we have gone ____ miles. ninety-nine

26. c b a
[0][9][9]
9 is as high as column b goes. If columa b is increased by one a 1 will appear in column ____ and the numbers in column b will start again at 0. c

27. 

If we go one mile more the numbers in column a and column b will start again at _____. 0

28. What happens on the mileage indicator in a speedometer is the same as what happens when we count. A mileage indicator is an instrument which _____ miles. counts

29. Now suppose that for some reason there are no more 9's in the world and so the numbers on the mileage indicator only run up to 8. The numbers we have then are 0, 1, 2, 3, 4, 5, __, __, and __. 6, 7, and 8

30. If 8 is the highest number, we have only ____ different digits, 0, 1, 2, 3, 4, 5, 6, 7, 8. Remember: 0 is a digit, too. nine

31.

8 is the highest number we have. When column a reaches 8, if we keep on going, a 1 will appear in column b and column a will begin again at _____. 0

32. Now suppose that the highest number is 7 and there are no more 8's and 9's. The only numbers we have are 0, 1, 2, 3, 4, __, __, and __. 5, 6, and 7

33. Remembering the 0, when 7 is the highest digit we have there are only _____ digits. eight

34.

If the highest digit we have is 7, then the numbers in column a cannot go higher than the digit____. This means that column a cannot indicate more than _____ (quantity) miles. 7, seven

35. The highest number we have is 7. When the indicator shows a 7 in column a

and we keep going, a 1 appears in column b and the numbers in column a begin again at _____. 0

APPENDIX C

36. When the highest number we had was 9 (b a: 0 9) (read "oh nine") meant we had gone nine miles. (b a: 1 0) (read "one oh") meant we had gone ____ miles.

ten

37. If the highest number we have is 7, (b a: 0 7) (read "oh seven") means we have gone seven miles. We go one mile farther and the indicator reads (b a: 1 0) (read "one oh"). This means we have gone _____ miles.

eight

38. If our numbers only go up to 7, then (b a: 0 7) means we have gone seven miles. (b a: 1 0) means we have gone eight miles. The next higher, (b a: 1 1) (read "one one") means we have gone ____ miles.

nine

39. Remember, at the beginning, when we were using numbers running up to 9, we said that column a represented "single miles" and column b represented "ten miles." Thus, (b a: 0 2) meant we had gone a)_____ miles. (b a: 2 0) meant we had gone b)_____ miles.

a) two
b) twenty

40. Now let us return to the situation in which there were no 9's and the highest number we had was 8. If we had traveled eight miles this would show as an ____ in column a. (b a: 0 1)

8

41. The highest number we have is 8. If we traveled eight miles the indicator would read (b a: 0 8). If we travel one mile more it will read (b a: 1 0). We will have gone _____ miles.

nine

42. The highest number we have is 8. If we travel eight miles the indicator reads (b a: 0 8). If we travel nine miles it reads (b a: 1 0). If we travel ten miles, it will read (b a: ___)

11

APPENDIX C

43. When the highest number we had was 9, a reading of b a 1 0 meant we had gone ten miles. When the highest number we have is 8, a reading of b a 1 0 means we have gone _____ miles.

nine

44. When the highest number we had was 9, we said that column a represented single miles and column b represented "ten miles." An indicator reading b a 2 4 meant we had gone twenty-four miles, or 2 times _____ plus 4 times one.

ten

45. When 8 is the highest number we have b a 0 8 means eight miles and b a 1 0 means _____ miles. It is obvious that column b no longer counts by tens.

nine

46. When the highest number we have is 8,

b a
1 0 means nine miles
2 0 means eighteen miles
3 0 means twenty-seven miles

Column b no longer counts by tens. It now counts by _____.

nines

47. If the highest number we have is 8, then column b represents "nine miles" so that an indicator reading of b a 1 0 means 1 times nine plus 0 times one or _____ miles.

nine

48. If the highest number we have is 8 and column b represents "nine miles" then an indicator reading of b a 2 3 means we have gone 2 times nine or _____, plus 3 times one or three; a total of twenty-one miles.

eighteen

49. Now suppose that the highest number we have is 1. This means that we have only _____ different digits, 0 and 1. We shall see how our mileage indicator would count miles using only two digits.

two

50. If we hadn't gone any distance our mileage indicator would read b a 0 0. That means we have gone _____ miles.

zero or no

APPENDIX C

51. b a
| 0 | 1 |
We now have only two digits, 0 and 1. When we have gone one mile, the digit ____ appears in column a of our mileage indicator. 1

52. Our mileage indicator reads b a
| 0 | 1 |
. We keep on going. The highest number we have is 1. When we have gone another mile, the digit ____ appears in column a, and the numbers in column a begin again at 0. 1

53. The highest number we have is 1. Our mileage indicator reads b a
| 1 | 0 |
. We have gone ____ miles. two

54. The highest number we have is 1.

b a

0	0	zero miles
0	1	one mile
		two miles

10

55. Our mileage indicator reads b a
| 1 | 0 |
. This means we have gone two miles. We go another mile. It now reads b a
_____. 11

56. The highest number we have is 1. Our mileage indicator reads b a
| 1 | 1 |
. This means we have gone ____ miles. three

57. Bi means two. You might guess that a system of numbering which is called "binary" has only ____ digits. two

58. When 1 is the highest number we have, the mileage indicator counts the miles in a binary or ____ digit system. two

59. A review of decimal counting will be helpful in learning binary counting. Fill in the blanks:
98, 99, ___, ___, 102, 103, 104, 105, 106, 107, 108, ___, ___, ___, 112, 113, etc.

100 101 109 110 111

APPENDIX C

60. Still counting in the decimal system, fill in the blanks: 999, ____, ____, 1002, 1003, 1004, 1005, 1006, 1007, 1008, 1009, ____, ____, 1012.

1000, 1001
1010, 1011

61. When the highest number we had was 9, if our indicator read b a and we went one mile farther the digit ____ appeared in column b and column a began again at 0.

b	a
0	9

1

62. Now the highest number we have is 1. When we go three miles the indicator reads c b a . If we go one mile farther columns b and a begin again at 0 and a ____ appears in column c.

c	b	a
	1	1

1

c	b	a
1	0	0

63. At four miles our indicator reads

c	b	a
1	0	0

. We go another mile. Now it reads

c	b	a

101

64. Binary number

0 0	zero miles
0 1	one mile
a)____	two miles
b)____	three miles

a) 10
b) 11

65. Binary number

10	two miles
11	three miles
____	four miles

100

66. Binary number

100	four miles
___	five miles

101

67. Binary number

100	four miles
101	five miles
___	six miles
111	seven miles

110

68. The binary number 10 (read "one oh") is equal in quantity to the decimal number ____. 2

69.

Quantity	Binary number
zero	0
one	1
two	10
three	11

Quantity	Binary
four	
five	101

100

70.

Quantity	Binary number
four	100
five	101

Quantity	Binary
six	110
seven	
eight	1000

111

71.

Quantity	Binary number
eight	1000
nine	
ten	1010
eleven	

1001
1011

72. To count is to add one to the previous number. Count from 1010 in the binary system: 1010, 1011, ____, ____. 1100
1101

73. Count in the binary system: 0, 1, 10, 11, 100, 101, 110, 111, ___, ___, ___. 1000
1001
1010

74. In the binary system, b a equals the quantity

1	0

two, or 1 times two plus 0 times one. Column b represents tens in the decimal system. In the binary system it represents _____. twos

75. The binary number 110 equals the decimal number 6. The binary number 111 equals the decimal number ____. 7

76. c b a

If the highest number we have is 1, column a represents ones, column b represents two.

1 one
10 two
100 four

fours

Column c must represent _____.

APPENDIX C

77. With decimal numbers, when we add two digits like $\begin{array}{r} 9 \\ +\,7 \\ \hline 16 \end{array}$ we write the 6 in one column and carry the digit ___ into the next column.

1

78. With decimal numbers, when we add $\begin{array}{r} b\ a \\ 1\ 9 \\ \quad 7 \\ \hline 6 \end{array}$ we write the 6 in column a and carry the 1 into the next column, adding it to the 1 in that column for a total sum of _6.

2

79. With the decimal numbers $\begin{array}{r} ba \\ 26 \\ +\,8 \\ \hline 34 \end{array}$

carried

In finding the sum we added 6 and 8, wrote the 4 in column a, _____ the 1 into column b and added it to the 2 already in that column.

80. $\begin{array}{r} b\ a \\ 1\ 9 \\ +\,1\ 5 \\ \hline 4 \end{array}$ The numbers in column a sum to 14. When this occurs we write a 4 in column a and a)_____ the 1 into column b and add it in that column. The sum in column b, then, is b)____.

a) carry
b) 3

81. In decimal addition, when the column sum is more than the largest digit we have, 9, we must ____ a number into the next higher column and add it to that column.

carry

82. $\begin{array}{r} b\ a \\ 1\ 7 \\ 1\ 7 \\ +\,1\ 7 \\ \hline \end{array}$ In this example, the sum in column a is 21. We write a 1 in column a, ____ the 2 into column b and add it in that column. The sum of 17 + 17 + 17 is _____.

carry
51

83. The rule for binary addition is much the same as for decimal addition, except that in binary addition the largest digit we have is ____.

1

84. $\begin{array}{r} b\ a \\ 1 \\ +\,1 \\ \hline 1\ 0 \end{array}$ For example, in adding 1 and 1 in the binary system, the sum is 10. We _____ the 1 into column b.

carry

85. When the sum in any column is greater than the largest digit we have, we must _____ a number into the next column and aid it to that column.

carry

86. In the binary system the number that is one higher than 1 is 10. Therefore, 1 + 1 must equal _____.

10

87. Binary addition

0	1	1	10
+ 0	+ 0	+ 1	+ 1
0	1	10	-

11

88. Binary addition

0	1	10	10
+ 0	+ 1	+ 1	+ 10
0	a)__	b)__	100

a) 10
b) 11

89. Binary addition

1	10	10	10
+ 1	+ 1	+ 10	+ 11
10	11	-	101

100

90. Binary addition

1	10	10	11
+ 1	+ 10	+ 11	+ 11
10	100	101	-

110

APPENDIX C

Preliminary Test: Binary Numbers

Subject #____.

Write the numbers for the following quantities in
a. the decimal system
b. the binary system

	Decimal	Binary
one	____	____
three	____	____
eight	____	____
eleven	____	____

Final Examination: Binary Numbers

The following problems involve the addition of binary numbers. The problems are written in binary numbers. Write the answers on your answer sheet in binary numbers.

1.
```
  101
+ 101
```

2.
```
   10
    1
+   1
```

3.
```
    1
    1
+   1
```

4.
```
   11
    1
+   1
```

5.
```
 1111
 1001
+1100
```

6.
```
 1011
 1101
 1110
+1001
```

7.
```
  111
+ 111
```

8.
```
  111
  011
  111
+ 111
```

APPENDIX C

The following problems involve the subtraction of binary numbers. The problems are written in binary numbers. Write the answers in binary numbers.

In binary subtraction:

0 - 0 = 0
1 - 0 = 1
1 - 1 = 0
10 - 0 = 10

9.
```
  10
- 1
```

10.
```
  11
- 1
```

11.
```
 100
- 10
```

12.
```
 1000
- 111
```

13.
```
 10101
- 1100
```

We have ten different digits in the decimal system. We might use a system with a different number of digits. Now you imagine a system in which there are only four digits: 0, 1, 2, 3. We called a two-digit system binary. A four-digit system is called a quaternary system. You know how to count in the decimal system, and you have learned how to count in the binary system.

14. Count from the quantity zero to the quantity ten in your four-digit or quaternary (0, 1, 2, 3) system.

15. Using your four-digit or quaternary system (0, 1, 2, 3), write the quaternary number that would represent the same quantity as the decimal number 18 does.

16. Write the quaternary number that represents the same quantity that the binary number 111 does.

Following is a series of problems involving addition and subtraction in this four-digit (0, 1, 2, 3) system. All of the problems are written in quaternary numbers. Write your answers in quaternary numbers.

17. Add
```
 21
+ 22
```

18. Add
```
 12
+ 12
```

19. Add
```
 12
+ 13
```

20. Subtract
```
 21
- 3
```

21. In a nine-digit system, containing only the digits 0, 1, 2, 3, 4, 5, 6, 7, 8, the quantity ten would be written _____.

APPENDIX C

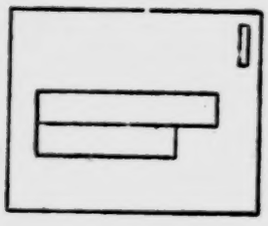
Instructions for Machine-Response Group

This is a teaching machine. We are engaged in a series of studies whose purpose is to find the most efficient ways of using a machine to teach certain materials. For this reason, we are teaching a number of experimental groups the same subject matter (a course in binary numbers) under differing experimental conditions.

The material to be learned will be presented as a series of 90 "items" or "questions," each of which is several sentences long, and contains a blank to be filled in, for example: "The solar system is composed of a sun and planets. The sun is at the center and the _____ revolve around it in orbits." The word which correctly fills in the blank is, of course, "planets."

After you have gone through a program of 90 items you will be given an examination on the material. It is your grade on this examination which we shall use as experimental data. The binary number program itself is set up in a "question-answer" form as a device to assist you in learning the material. For this reason, although it is probably possible to "cheat the machine," it is not advisable since it may impair your final performance.

The machine looks like this:



Turning the wheel away from you advances the program. You are to do the following:

a. Move each item into the "question" window and read it.

b. You will be given a numbered sheet on which to write your answers. The numbers correspond to the item numbers. Write the word or number which correctly fills in the blank. There may be more than one blank... write your answer next to the item number, not a new number.

c. Now move the item into the "question and answer" window. The correct answer, which was covered in the question window, will now be visible. Please do not change your answer, even if it was very close to the correct one.

d. Go on to the next item in the same manner. The paper will move in a forward direction only. Moving it backward will cause it to tear. Please avoid this.

APPENDIX C

Answer every item... do not leave blanks. Do not hesitate to guess at an answer if you are not sure. It is your grade on the final with which we are concerned. Errors in the program do not count against you, but are of interest to us in terms of refining the program.

When you are finished, come out and ask the experimenter for the examination.

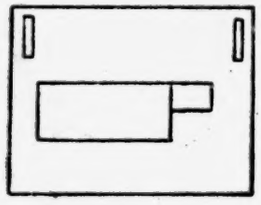
If you have any questions, or if anything at all seems to be wrong, call in the experimenter immediately.

Instructions for Machine--No-response Group

This is a teaching machine. We are engaged in a series of studies whose purpose is to find the most efficient ways of using a machine to teach certain materials. For this reason, we are teaching a number of experimental groups the same subject matter (a course in binary numbers) under differing experimental conditions. The material to be learned will be presented as a series of 90 "items," each of which is several sentences long.

After you have gone through a program of 90 items you will be given an examination on the material. Your grade on this examination will be used as experimental data.

The machine looks like this:



Turning the wheel away from you advances the program. Move each item into the window, read it, and then go on to the next item. The paper will move in a forward direction only. Moving it backward will cause it to tear. Please avoid this. When you are finished, come out and ask the experimenter for the examination.

If you have any questions, or if anything at all seems to be wrong, call in the experimenter immediately.

APPENDIX C

Instructions for Booklet-Response Group

You will be given a booklet containing a brief course in binary numbers. The material will be presented as a series of 90 "items" or "questions," each of which is several sentences long, and contains a blank to be filled in, for example: "The solar system is composed of a sun and planets. The sun is at the center and the _____ revolve around it in orbits." The word which correctly fills in the blank is, of course, "planets."

After you have gone through a program of 90 items you will be given an examination on the material. It is your grade on this examination which we shall use as experimental data. The learning material itself is set up in a "question-answer" form as a device to assist you in learning. For this reason, although it is certainly possible to "cheat" it is not advisable, since it will impair your final performance.

The "items" will be written on the left-hand side of each page and the answers will be written in a column at the right. You are to do the following:

a. Read each item, but conceal the answer and all other items.

b. You will be given a numbered sheet on which to write your answers. The numbers correspond to the item numbers. Write the word or number which correctly fills in the blank. There may be more than one blank... write your answer next to the item number, not a new number.

c. Now reveal the correct answer. Please do not change your answer even if it was very close to the correct one.

d. Go on to the next item, following the same procedure: read it, write your answer, reveal the correct answer. Do not review or go back in any way. Read one item after another in sequence. The purpose of this is to make your data comparable to that of other subjects to whom the material is presented in frames. They can see only one item at a time and cannot go back to items they have already read.

Answer every item... do not leave blanks. Do not hesitate to guess at an answer if you are not sure. It is your grade on the final with which we are concerned. Errors in the program do not count against you, but are of interest to us in terms of refining the program.

When you are finished, come out and ask the experimenter for the examination.

If you have any questions, or if anything at all seems to be wrong, call in the experimenter immediately.

APPENDIX C

Instructions for Booklet--No-response Group

You will be given a booklet containing a brief course in binary numbers. The material to be learned will be presented as a series of 90 "items" each of which is several sentences long.

After you have gone through a program of 90 items you will be given an examination on the material. Your grade on this examination will be used as experimental data.

As you read each item, conceal all other items on the page. Read one item after another in sequence. Do not review or go back in any way. The purpose of this is to make your data comparable to that of other subjects to whom the material is presented in frames. They can see only one item at a time and cannot go back to items they have already read.

When you are finished, come out and ask the experimenter for the examination. If you have any questions, or if anything seems to be wrong, call in the experimenter immediately.

Table 12

Analysis of Variance of Response--No-response and Machine, Booklet Conditions from Experiment IIB

Source	df	SS	F
Response	1	19.27	1.02
Device	1	13.07	-
R x D	1	32.27	1.71
Within cells	56	1054.80	
Total	59	1119.41	

APPENDIX D

Table 13

Analysis of Variance of Preliminary Test Data for the Three Pacing Conditions of Experiment III

Source	df	SS	F
Between Groups	2	24.85	3.30*
Within Groups	42	157.73	
Total	44	182.58	

* .05 level

Table 14

Analysis of Covariance of Fill-ins and Total Test Scores Adjusted for Preliminary Test Scores

		Fill-ins Test		Total Test	
Source	df	SS	F	SS	F
Between Groups	2	4.75	1.04	6.05	
Within Groups	41	92.88		361.46	
Total	43	97.63		367.51	

APPENDIX E

The Multiple Sensory Stimulation Trainer
Device X-11-H-20

General Description

The Multiple Sensory Stimulation Trainer is a teaching machine in which questions are presented to the trainee either visually or aurally, or in which the visual and aural presentation may be simultaneous. The trainee writes the answer on a paper strip, following which the answer is presented visually or aurally.

The device is enclosed in a small desk-like console. The trainee, sitting at the device, has a flat shelf approximately 13" x 24" in size in front of him. At the rear of this shelf a sloping panel rises at a 45° angle. The visual questions and answers are centrally presented in a horizontal window in this panel. The answers are written on a paper strip fed to an aperture located on the right side of the flat shelf. Control buttons, lights, selector switch, and power switch are located on the sloping panel.

The controls consist of: a question ready light, an answer ready light, a recorder on light, a question button, an answer button, a selector switch for selecting sequence of operation, namely, visual only, audio only, and visual and audio, a power on switch, fuse, and a power on indicating light.

At the right of the cabinet, below the paper strip aperture, a phone jack is located, permitting the presentation to be either by loud speaker, or by inserting earphones for privacy. On the right side of the sloping cabinet to the front, a switch is located to move the paper manually. (NOTE: The paper is not to be pulled in order to get the record of the answer.) On the left side, to the rear of the cabinet, a switch is located to move the drum manually.

On the relay chassis, at the bottom, inside the cabinet, a panel with two (2) lights and a switch is located to indicate the position the tape is in. When the question part of the tape is in position to run, the question light is on. After the tape has started, the answer lamp lights, indicating that the device is ready to operate the answer.

APPENDIX E

Sample of Psychology Program

1. A doctor taps your knee (patellar tendon) with a rubber hammer to test your _____.	reflexes (or reflex)
2. If your reflexes are normal, your leg _____ to the tap on the knee with a slight kick (the so-called "knee jerk").	responds (or reacts)
3. In the knee jerk or patellar tendon reflex, the kick of the leg is the _____ to the tap on the knee.	response (or reaction)
4. The stimulating object used by the doctor to elicit a knee jerk is a(n) _____.	hammer (or mallet)
5. The stimulus which elicits a knee jerk is the _____ delivered by the so-called "stimulus object" or hammer.	tap (or blow)
6. In the knee jerk reflex, we call the rubber hammer the (1) _____ and the tap on the knee (2) _____.	(1) stimulus object (2) stimulus
7. An event is explained when its cause is identified. The "cause" or explanation of the knee jerk is, technically, the _____ which elicits it.	stimulus (tap on the knee)
8. Technically speaking, a reflex involves a process called elicitation. A stimulus _____ a response.	elicits
9. To avoid unwanted nuances of meaning in popular words, we do not say that a stimulus "triggers," "stimulates," or "causes" a response, but that it _____ a response.	elicits

APPENDIX E

Preliminary Test: Psychology

Pavlov trained dogs to salivate in response to a bell.

1. What is this training process called?
2. What is the bell called (technical term)?
3. When the training is complete, salivation is referred to as a _____.

Final Test: Psychology

Write on your answer sheet. Do not write on this.

1. When a small particle enters and irritates the eye, the eye automatically blinks. The blink is called a _____.
2. Through the process of _____ ____ the eyeblink can be made to occur to a neutral stimulus such as the ringing of a bell.
3. The bell would be called a _____.
4. The small particle referred to above is called a(n) _____.
5. The small particle _____ the eyeblink.
6. When food is presented to a hungry dog, a brief time elapses before the dog salivates. This time interval is called the _____.
7. For a "knee-jerk" to occur the tap on the knee must be strong enough to exceed the _____.
8. and 9. The stronger the (8)_____, the shorter will be the (9)_____ of the response.
10. The process of associating the words roast beef with the response of salivating is called _____.
11. and 12. The actual roast beef would be the (11)_____ and the words roast beef would be the (12)_____.
13. Which would be presented first, the words or the actual roast beef?
14. How can the salivation response to the words roast beef be weakened?
15. What is the technical name for this weakening process?

APPENDIX E

16. and 17. Given a neutral object and a painful stimulus, describe how a child can be made to fear the neutral object. (Use the back of your answer sheet if you run out of space. Be brief.)

18. In the above situation the neutral object is called a _____ (technical term).

19. and 20. What would be done to reduce the child's fear of the neutral object? (Use the back of your answer sheet if necessary. Be brief.)

21. If the fear was not reduced, we would say that it was resistant to _____.

Please do not discuss this experiment. It is important that our subjects do not have advance information.

NAVTRADEVCEN 507-3

APPENDIX E

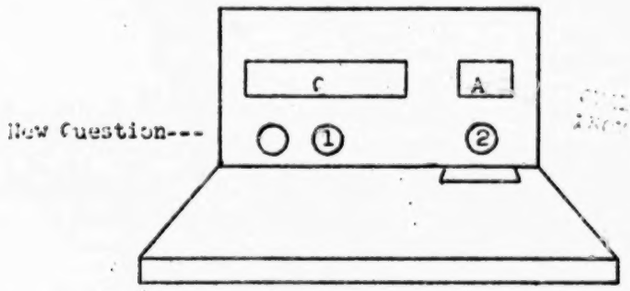
Instructions: Elaborate Machine

This is a teaching machine. We are engaged in a series of studies whose purpose is to find the most efficient ways of using a machine to teach certain materials. For this reason, we are teaching a number of experimental groups the same subject matter [a course in psychology (binary numbers)] under differing experimental conditions.

The material to be learned will be presented as a series of 90 "items" or "questions," each of which is several sentences long, and contains a blank to be filled in, for example: "The solar system is composed of a sun and planets. The sun is at the center and the _____ revolve around it in orbits." The word which correctly fills in the blank is, of course, "planets."

After you have gone through a program of 90 items you will be given an examination on the material. It is your grade on this examination which we shall use as experimental data. The psychology program itself is set up in a "question-answer" form as a device to assist you in learning the material. For this reason, although it is probably possible to "cheat the machine," it is not advisable since it may impair your final performance.

The front of the machine cabinet will look like this:



In general:

1. Pressing the New Question button will advance the machine internally to the next question.

2. Pressing button 1 will cause the machine to present the question to you.

3. Pressing button 2 will cause the machine to present the answer to you.

When the machine is ready, the button to be pressed will light up. Do not press any button that is not lit up. After the button has lit up you may press it whenever you are ready, but you must wait until the button is lit.

When the experimenter turns on the machine you will see instructions

in window C. Read them and then go on to question 1 by pressing the New Question button and then button 1.

You will see the question in window Q. Read it and write your answer on the answer tape. When you are ready, and when button 2 has lit up, press it to call for the answer. The answer will appear in window A. Read it, and then reread that sentence in the question in which the blank occurs.

When you are ready, and when the New Question button has lit up, continue with question 2, etc., in the same manner. When you reach question 30 you will have to call the experimenter in to change the tape. There will be a note in that question to remind you.

If anything at all seems to be wrong with the machine, call the experimenter in immediately.

Answer every item in the program. Do not leave any blanks. Do not hesitate to guess if you are not sure.

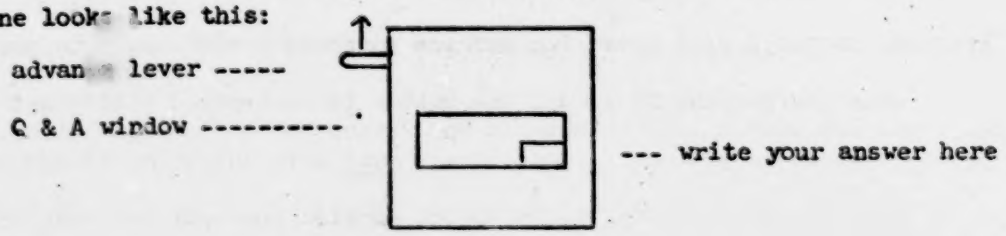
Instructions: Crude Machine

This is a teaching machine. We are engaged in a series of studies whose purpose is to find the most efficient ways of using a machine to teach certain materials. For this reason, we are teaching a number of experimental groups the same subject matter [a course in psychology (binary numbers)] under differing experimental conditions.

The material to be learned will be presented as a series of 90 "items" or "questions," each of which is several sentences long, and contains a blank to be filled in, for example: "The solar system is composed of a sun and planets. The sun is at the center and the _____ revolve around it in orbits." The word which correctly fills in the blank is, of course, "planets."

After you have gone through a program of 90 items you will be given an examination on the material. It is your grade on this examination which we shall use as experimental data. The psychology program itself is set up in a "question-answer" form as a device to assist you in learning the material. For this reason, although it is probably possible to "cheat the machine," it is not advisable since it may impair your final performance.

The machine looks like this:



APPENDIX E

A printed "item" or "question" will appear in the window. Read it, and then write your answer. Then move the advance lever slowly toward the back of the machine. This will reveal the correct answer and move your answer under a strip of glass. Read the correct answer and then reread that sentence in the question in which the blank occurs.

Now move the advance lever again, slowly. The next item should appear in the window. Follow the same procedure. If anything at all goes wrong with the machine, or if you cannot see an item or its answer, call in the experimenter immediately.

Instructions: Programmed Booklet

You will be given a booklet containing a brief course in binary numbers (psychology). The material will be presented as a series of 90 "items" or "questions" each of which is several sentences long, and contains a blank to be filled in, for example: "The solar system is composed of a sun and planets. The sun is at the center and the _____ revolve around it in orbits." The word which correctly fills in the blank is, of course, "planets."

The "items" will be written on the left-hand side of each page and the answers will be written in a column at the right. You are to do the following:

a. Read the item, but conceal the answer and all other items.

b. You will be given a numbered sheet on which to write your answers. The numbers correspond to the item numbers. Write the word or number which correctly fills in the blank. There may be more than one blank... write your answer next to the item number, not a new number.

c. Now reveal the correct answer. Read it and reread the sentence in which the blank occurred. Please do not change your answer, even if it was very close to the correct one. It is particularly important that we see which items subjects tend to get wrong, so that we may modify them.

d. Go on to the next item, following the same procedure: read it, write your answer, reveal the correct answer, reread the sentence with the blank. Do not review or go back in any way. Go right on from one item to the next.

After you have gone through a program of 90 items you will be given an examination on the material. It is your grade on this examination which we shall use as experimental data. The learning material itself is set up in a "question-answer" form as a device to assist you in learning. For this reason, although it is certainly possible to "cheat," it is not advisable since it will impair your final performance.

Ask the experimenter if there is anything you are not sure of.

APPENDIX E

Table 15

Mean Days (and SDs) between Sessions for the Subjects in the Various Conditions of Experiment IV

	Elaborate Machine				Crude Machine				Booklet			
	Psychology		Binary		Psychology		Binary		Psychology		Binary	
	Coll.	H.S.	Coll.	H.S.	Coll.	H.S.	Coll.	H.S.	Coll.	H.S.	Coll.	H.S.
Mean	3.80	3.00	11.20	5.00	5.40	4.40	7.80	10.00	9.80	6.20	13.00	6.80
SD	4.76	3.94	5.80	2.77	2.19	3.29	5.54	4.44	4.09	2.86	13.00	1.92

Table 16

Analysis of Variance of the Days between Sessions

Source	df	SS	F
Devices (machines, booklet)	2	91.63	1.33
Order of Program	1	216.60	6.30*
Educational Level	1	81.67	2.37
Device x Order	2	28.30	-
Device x Education	2	91.43	1.33
Education x Order	1	4.27	-
Device x Education x Order	2	50.63	-
Within Cells	48	1650.80	
Total	59	2215.33	

* .05 level

APPENDIX E

Table 17

Analysis of Variance of Education Level, Device, Session, and Program Conditions for Experiment IV (Based on T Scores)

Source	df	SS	F
Device (machines. booklet)	1	1810.41	1.25
Education Level	2	289.53	15.62**
Education x Device	2	107.16	-
Between Ss in Same Group (E)	54	6261.02	
(Total Between Ss)	(59)	(8468.12)	
Session	1	2.44	-
Session x Education	1	1.34	-
Session x Device	2	136.52	1.64
S x E x D .	2	204.68	2.42
Session x Ss Within Groups (E)	54	2285.85	
(Within Ss)	(60)	(2633.03)	
Program	1	-	-
Program x Device	2	94.00	1.03
Program x Education	1	47.00	1.03
P x D x E	2	20.50	-
Program x Ss Within Groups (E)	54	2471.13	
(Within Ss)	(60)	(2632.63)	

Note: (E) indicates error term used in obtaining F's.

**.01 level

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